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Managing Young Stands for Firewood

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INTRODUCTION

The renewed interest in the use of wood for fuel has created an opportunity to apply forestry practices to young stands of hardwoods for the maximum production of lumber and veneer. Hardwood poletimber 5 to 10 inches in dbh, traditionally, the size class in which timber stand improvement measures are applied, is now being looked at as the primary source of firewood. Pole stands have a greater capacity to respond to thinning than those of sawtimber or smaller size classes. A thinning properly applied can capitalize on this potential while one improperly applied can reduce growth and jeopardize the production of the higher value products.

The purpose of this paper is to encourage the practicing forester to become proficient in managing young stands. This includes analyzing stands, preparing prescriptions, marking timber, estimating volume, and evaluating thinning operations. Foresters can play an important role in harvesting firewood—to what extent is highly dependent on their expertise in thinning young stands.

SILVICULTURAL GUIDES

Foresters in the Northeast now have for field use practical silvicultural guides for all major timber types in the region. One of the glowing features of these guides is that they summarize existing knowledge and present it in a usable format. Thus, their use in managing a stand for firewood production assures the forester that he is up to date technically and applying the best information available. Silvicultural guides for northern hardwoods, paper birch, and upland central hardwoods (oaks) are those with which foresters should be most familiar in managing young hardwood stands for firewood.

Exhibit 1
DIAGNOSTIC TALLY SHEET FOR POLETIMBER AND SAWTIMBER STANDS

Cumulative Tally—Number of Trees Per Acre (B.A. Factor 10).

Number of Trees	Diameter Breast Height												
	2	4	6	8	10	12	14	16	18	20	22	24	26+
1	458	115	51	29	18	13	9	7	6	5	4	3	3
2	917	229	102	57	37	25	19	14	11	9	8	6	5
3	1375	344	153	86	55	38	28	21	17	14	11	10	8
4	1834	458	204	115	73	51	37	29	23	18	15	13	11
5	2292	573	255	143	92	64	47	36	28	23	19	16	14
6	2750	688	306	172	110	76	56	43	34	27	23	19	16
7	3209	802	357	201	128	89	65	50	40	32	27	22	19
8	3667	917	407	229	147	102	75	57	45	37	30	25	22
9	4125	1031	458	258	165	115	84	64	51	41	34	29	24
10	4584	1146	509	287	183	127	94	72	57	Tally		Number	
11	5042	1260	560	315	202	140	103	79	62	Legend		Plots	
12	5501	1375	611	344	220	153	112	86	68	/			
13	5959	1490	662	372	238	165	122	93	74	0			
14	6417	1604	713	401	257	178	131	100	79	X			
15	6875	1719	764	430	275	191	140	107	85				
Totals # Trees													
B.A.													

Total Number of Trees Per Acre—Add the last figure used in each block and divide by the number of point samples tallied.
B.A. Per Acre—Add the total number of entries by species or groups of species, multiply by 10, and divide by the number of point samples tallied.

STAND DESCRIPTION (Even-age)

STAND PRESCRIPTION

Number of trees per acre _____

Mean stand DBH _____

Total basal area per acre _____

Basal area, B level _____

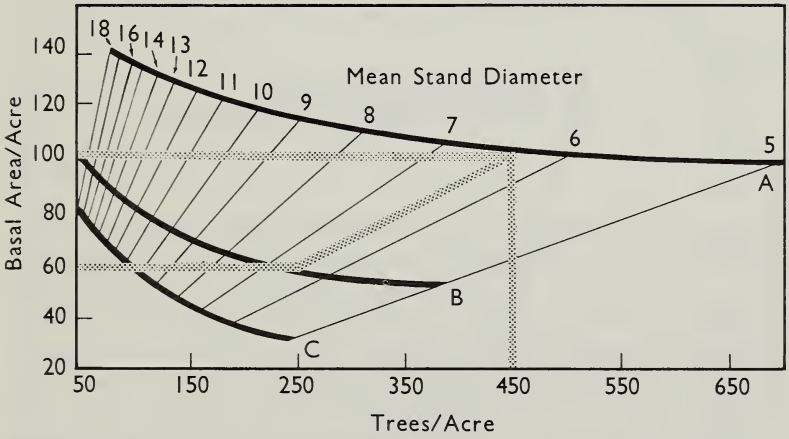
SITE INDEX

	Species:		
Age			
Height			
Site Index			

STAND ANALYSIS FOR HARDWOOD POLE STANDS

The use of a silvicultural guide requires that each stand be examined closely or cruised to gather field data. The Diagnostic Tally Sheet (Exhibit 1) is used to determine both the number of trees and basal area per acre from 5 to 10 prism plots systematically located over the area being considered for treatment. If stands are not uniform, one might have to stratify into uniform conditions to keep the number of plots needed to a minimum. These values—number of trees and basal area per acre—are plotted on the appropriate stocking chart (Fig. 1), and the recommended level of management (B level) is established. As an example, a stand of northern hardwoods averaging 450 trees and 100 square feet (ft^2) of basal area per acre intersects on the stocking chart slightly below the A line. From this point, follow diagonally, parallel to the nearest broken line of mean stand diameter, and mark the point at which the B line is intersected. From this point, draw a horizontal line to the

NORTHERN HARDWOOD STOCKING CHART



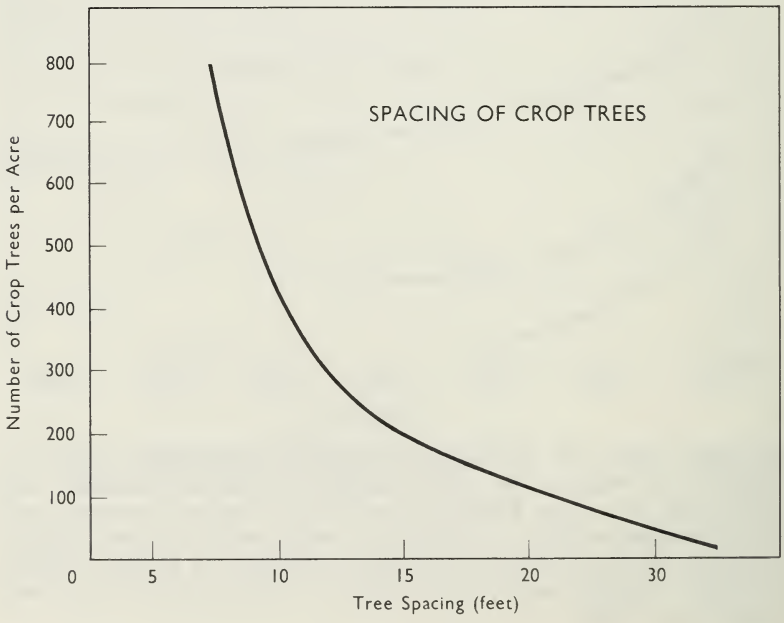
Stocking chart for even-aged northern hardwoods based on number of trees in the main canopy, average diameter, and basal area per acre. Stands above the A line are overstocked. Stands between the A and B line are adequately stocked. Stands between the B and C line should be adequately stocked within 10 years. Stands below the C line are definitely understocked (Leak et al 1969).

vertical ordinate for the basal area at this level, which is 60 square feet. The mean stand diameter is 6.3 inches dbh, or the point at which the A line is intersected.

Stand data that fall near the A line are considered to be at the upper limit of stocking. The trees are quite crowded and diameter growth is slow. The B line represents minimum stocking for full-site utilization. Diameter growth is rapid and volume growth per acre remains high. Stands that lie much below the B line would show diminished volume growth per acre.

Stands at the halfway point, between the A and B line and above, are prime candidates for a thinning operation. In thinning such stands, the stocking is reduced to the B line but not below. As a minimum, the thinning should result in the removal of 20 to 25 ft^2 of basal area, which represents 5 or more cords per acre. The stand prescription is essentially the difference between the present stocking and B level. It can be expressed in square feet of basal area and the number of trees per acre to be removed or in spacing of the residual crop trees. Approximate spacing of crop trees can be determined by using Exhibit 2.

Exhibit 2



As basal area is the controlling mechanism in the thinning of hardwood pole stands for firewood, successive checks of the marking intensity should be made during the marking operation. This is particularly important where inexperienced markers are used. Periodic prism estimates of the "residual stand after marking" are effective training exercises and the best way to ensure that the intended basal area goal is not exceeded. As foresters become more experienced, the prism check can become less frequent.

The final product of the thinning measure is stand stocking after the harvest. As the intent is to develop a stand close to the B line, the residual basal area should be related to this level using the stocking chart. By taking at least 5 prism plots to record basal area and plotting the information on the appropriate stocking chart using basal area and mean stand diameter (estimated), this comparison can be made quickly.

It is well to keep in mind that the intended goal of thinning is to develop an adequately stocked stand with an even distribution of crop trees. Creating an understocked condition below the B level defeats the purpose of thinning for increased growth and quality production. Also, regeneration is of no concern in thinning pole stands because of the young age of the stands. Therefore, patch cutting and group selection have no place in the application of the thinning measure.

THE SOFTWOODS

White Pine

The firewood market enables one to increase the white pine component of many stands on lighter, sandy soils. White pine seedling and saplings growing in the understory of hardwoods on a pineland site (hardwood site index 59 or less) will respond to a release and increase quality growth (Lancaster and Leak 1978). Pine seedling or saplings with a full, healthy crown of needles and a crown of 30 percent or more of total height will respond almost immediately to a release. Smaller crowned, sparsely needled trees will have a period of crown development of up to 5 years before they respond to a release.

Experience has taught us that in areas where there are sufficient numbers of stems (800 or more per acre, 4.5 feet tall or taller), the removal of the hardwood overstory will result

in excellent stands of white pine. The reason for this is that there are sufficient white pine stems to ensure early crown closure. Once crown closure occurs, the impact of the white pine weevil is less severe because of the compaction of the crowns caused by side competitors. This early release is the best way to obtain full, rapid production of white pine and to condition the stand to withstand the damaging effects of the weevil.

Where the stocking of white pine is insufficient to ensure early crown closure or where the component of pine is sufficient but made up of small-crowned, sparsely needled trees, the hardwood overstory can be removed in a series of two or more cuts depending on stocking and the development of white pine.

The quadrat system can be used to determine the stocking of white pine seedling and saplings. A series of 1/250-acre quadrats (7.45-foot radius) up to a maximum of 50 plots will provide the necessary information as to number of trees. For an average stocking of 800 stems per acre, there should be an average of 3.2 white pine seedling or saplings per plot. As a minimum, five cords per acre should be removed in each harvest operation. Also, size of the harvest equipment should be restricted to avoid excessive damage to the pine. Horse logging should be encouraged.

Spruce-fir

Hardwoods scattered among spruce-fir stands are an excellent source of firewood if there is sufficient volume to pay for the operation. On the primary softwood sites—those with poor or impeded drainage—hardwoods are less competitive and usually make up less than 25 percent of the stand, offering fewer opportunities for a firewood operation than secondary sites (Frank and Bjorkbom 1973). On these better drained sites, hardwoods are more aggressive and mixed stands of hardwood and spruce-fir are more common. Where there is sufficient stocking of the softwoods (C level or above) to favor spruce-fir management, the firewood market can play an important role.

In marking these areas for harvest, stocking is reduced to B level or close to it. In some instances, it may be necessary to leave hardwood and less desirable species to avoid an understocked situation. To protect against windthrow, no more than 30 to 50 percent of the basal area should be removed at any one

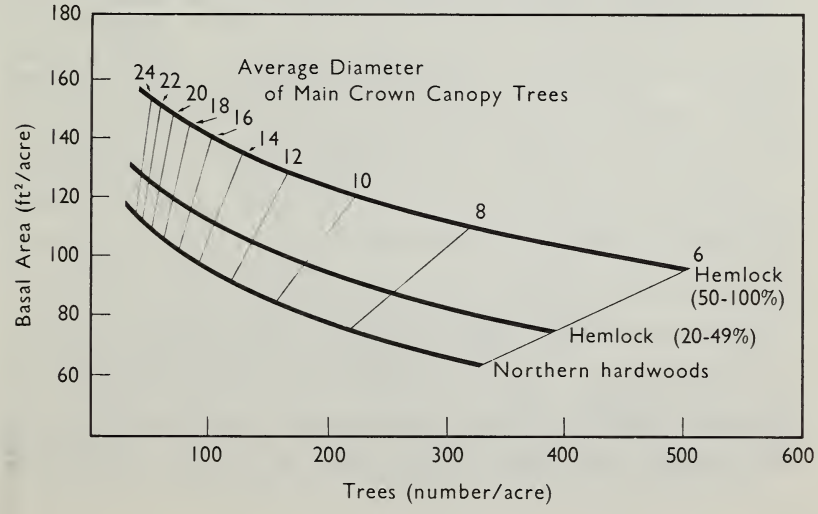
time. Light, frequent cuts with small openings favor spruce and fir establishment, while heavier cuts with large openings favor hardwoods and generate more competition with softwoods.

Hemlock

In hardwood areas where the proportion of hemlock is 20 percent or more, marking intensity is in proportion to the amount of hemlock to be left. Growing space requirements of hemlock are not as great as those of the hardwoods so residual stocking can be higher. The stocking chart (Fig. 2) for even-aged hemlock-hardwoods identifies these higher levels of management in relation to the proportion of hemlock in the stand. As an example, a stand with the main crown canopy trees averaging 6 inches in diameter and with 20 to 49 percent hemlock would be marked to favor the hemlock to a residual stocking of 75 ft^2 of basal area of both hemlock and hardwoods. Stands with more than 50 percent hemlock are managed to 95 ft^2 of basal area.

HEMLOCK-HARDWOOD STOCKING CHART

Stocking levels for even-aged hemlock-hardwood stands in the Lake States by basal area and number of trees for specified diameter classes and certain percentages of hemlock and hardwoods (Tubbs 1977).



WILDLIFE CONSIDERATIONS

In most cases, thinning a well-stocked stand of poletimber creates diversity in the understory and increases its value to wildlife. If done with proper planning and care, these operations can benefit wildlife in other ways as well.

The nuts and fruits or mast produced in a forest are an important food source for a variety of wildlife. Acorns and nuts make up a major portion of the hard mast production. They are important to squirrels, deer, turkey, bear, and other species. In stands of mixed hardwoods, leave as many of the oaks, hickories and other mast producers as is feasible. Leave the largest, dominant mast producing trees and remove surrounding trees that compete for dominance. Leaving a mixture of oaks and other mast producers will ensure against a total mast failure in a given year.

As the trees grow older, cavities will develop that are important to squirrels, songbirds, and other wildlife. In pole-size timber, cavities require 8 to 30 years to develop. Suitable cavities generally will not be available until a stand is at least 40 years old. In thinning operations, some potential or existing den trees should be retained. Beech trees may develop cavities within 8 years after a limb 3 inches or larger has died; however, oaks may require 30 years or longer to develop sizeable cavities. Black gum and maples also are good species for early den development. Leave at least five potential cavity trees per acre in young stands to meet the needs of cavity-using wildlife.

Poletimber stands with their tight crown canopies and sparse understories are the least productive wildlife areas. Valuable food plants are shaded by the dense canopy. In many cases, reducing the basal area of a young stand from 120 ft^2 to B level can double the understory vegetation production.

Certain tree species in the midstory and understory have competing values in that they are especially useful to wildlife, but also have high heat value for firewood. Two such species are flowering dogwood and hop hornbeam. The landowner should be made aware of these conflicting values and if he is interested in wildlife, save as many of these species as possible.

Dead trees do not compete with the growing stock and may be left standing. Many of these may contain cavities that provide winter cover for a wide variety of birds and mammals and nesting sites during other times of the year. Dead trees

also contain an abundance of insects, an important food source for many forest-dwelling birds.

VOLUME CALCULATIONS

Determining cordwood volume is an integral part of the thinning process and, as stumpage prices continue to climb, is an increasingly important function.

There are essentially two methods used in estimating tree volumes—point sampling for area estimate sales and individual tree measurement. In point sampling, the Cumulative Volume Tally for Rough Cords (Exhibit 3) is used extensively and is still the most popular. Because diameter measurement is not critical in point sampling, a refinement of the cumulative tally has been developed where diameter need not be recorded (Exhibit 4). This improved tally is preferred in firewood sales because only an estimate of height is required of "in" trees. Another improvement in the tally is that species can be written in rather than identified by symbols.

Shortcut formulas are used in volume determination to a limited extent and are fairly accurate, if properly applied.

A sample of shortcut formulas for cruising cords of firewood using a 10-Factor prism or gauge (Ashley 1980):

- If trees average four 8-foot sticks or more (will apply in most cases),

$$\frac{\text{Number of 8-foot sticks in countable trees X .6}}{\text{Number of point samples}} = \text{Cords/acre}$$

- Cord — Basal area ratios by various average merchantable stand heights: [+]

  1, 8-foot stick: .089 cords to 1 ft^2
  2, 8-foot sticks: .143 cords to 1 ft^2
  3, 8-foot sticks: .195 cords to 1 ft^2
  4, 8-foot sticks: .249 cords to 1 ft^2
  5, 8-foot sticks: .302 cords to 1 ft^2

  To obtain cord volume, multiply ratio by number of square feet of basal area involved.

- Cubic-foot (ft^3) volume per acre, Site Index 60: [+]
  (Average stand diameter + 15[*]) basal area = ft^3
  (to convert to cords, divide by 80)

[+] Both formulas can be used to determine total volume or volume to be removed.

[*] For each 10-foot increase or decrease of site index, increase or decrease by 3.

The limiting factor in using point sampling for firewood sales is the difficulty in establishing an accurate acreage figure. The volume estimates are on a per acre basis and if the total acreage is not established correctly, a major source of error is introduced. Ten or more sample points are required to obtain reasonably accurate results. For a large firewood sale covering 50 acres or more, the point sampling method is appropriate.

Exhibit 3

CUMULATIVE VOLUME TALLY — ROUGH CORDS

(Basal area factor of 10)

FOREST_____ CRUISER_____ DATE_____

W.C._____ COMP._____ T._____ R._____ SEC._____ 40____

TYPE & CONDITION_____ ACRES_____ CULL_____

Points Tallied	Tree Tally at Point	D.B.H.	NO. OF 8′ BOLTS PER TREE — Variable top to 4″ d.i.b.								Tally Legend				Total Cords/ Acre
			1	2			3		4						
1		6	87	143	285	428	204	408	240	479	/				
			173	571	713	856	612	815	719	958	\				
2			260	999	1142	1284	1019	1223	1198	1437	o				
			347	1427	1570	1712	1427	1631	1677	1916	X				
3			433	1855	1998	2140	1835	2038	2156	2395	–				
			520	2283	2426	2568	2242	2446	2635	2874					
4			606	2711	2854	2996	2650	2854	3114	3353	5		6	7	
		8	89	143	287	430	195	390	249	499	304	608	332		
5			178	573	716	860	585	780	748	997	911	1215	665		
			267	1003	1146	1290	974	1169	1247	1496	1519	1823	997		
6			355	1433	1576	1720	1364	1559	1745	1995	2127	2430	1330		
			444	1863	2006	2150	1754	1949	2244	2493	2734	3038	1662		
7			533	2293	2436	2579	2144	2339	2743	2992	3342	3646	1995		
			622	2723	2866	3009	2534	2728	3241	3491	3949	4253	2327		
8			711	3153	3296	3439	2923	3118	3740	3989	4557	4861	2660		
		10	90	150	301	451	204	407	244	488	293	587	345	387	
9			180	602	752	902	611	814	732	976	880	1174	690	774	
			270	1053	1203	1354	1018	1221	1220	1464	1467	1761	1034	1161	
10			359	1504	1654	1805	1425	1629	1707	1951	2054	2348	1379	1548	
			449	1955	2105	2256	1832	2036	2195	2439	2641	2934	1724	1935	
11			539	2406	2557	2707	2239	2443	2683	2927	3228	3521	2069	2322	
			629	2857	3008	3158	2646	2850	3171	3415	3815	4108	2414	2709	
12			719	3309	3459	3609	3054	3257	3659	3903	4402	4695	2758	3096	
		12	89	154	308	462	210	420	252	504	287	573	331	382	
13			178	617	771	925	631	841	757	1009	860	1147	662	764	
			268	1079	1233	1387	1051	1261	1261	1514	1433	720	994	1147	
14			357	1542	1696	1850	1471	1682	1766	2018	2007	2293	1325	1529	
			446	2004	2158	2312	1892	2102	2270	2522	2580	2866	1656	1911	
15			535	2466	2621	2775	2312	2523	2775	3027	3153	3440	1987	2293	
			624	2929	3083	3237	2733	2943	3279	3532	3726	4013	2319	2675	
16		14	89	156	313	469	213	427	256	511	291	582	330	374	
			178	625	782	938	640	854	767	1022	873	1164	661	749	
17			267	1094	1250	1407	1067	1280	1278	1533	1456	1747	991	1123	
			356	1563	1719	1876	1494	1707	1789	2044	2038	2329	1322	1498	
18		16	87	158	315	473	215	430	263	526	301	602	336	380	
			175	631	789	946	645	860	789	1053	903	1204	672	760	
19			262	1104	1262	1420	1076	1291	1316	1579	1505	1806	1008	1140	
		18	88	160	319	479	216	432	266	532	313	626	340	368	
20			175	638	798	958	649	865	798	1064	939	1252	680	736	
		20	89	162	324	486	220	441	271	542	312	624	349	372	
			178	648	810	972	661	881	812	1083	936	1248	698	744	
TOT.		22	91	167	334	500	227	455	277	553	318	637	352	379	
			182	667	834	1001	682	910	830	1107	955	1273	704	758	

VOLUME IN ROUGH CORDS PER ACRE Multiply the sum of the last figures used in block by 0.01 and then divide the total by the number of point samples tallied.

Exhibit 4

CORDS PER ACRE OF
MERCHANTABLE STEMS OVER 5″ D.B.H. TO 4″ TOP

Basal area factor of 10

Spec.	NO. OF 8′ STICKS PER TREE																																						
	1				2						3								4								5						6				7		
	1	2	2	3	1	3	4	6	7	8	2	4	6	8	10	12	14	16	2	5	7	10	12	15	17	20	3	6	9	12	15	18	3	7	10	13	4	8	11
	4	5	6	7	10	11	13	14	16	17	18	20	22	24	26	28	30	32	22	25	27	30	32	35	37	40	20	23	26	29	32	35	17	20	24	27	15	19	23
	8	8	9	10	18	20	21	23	24	25	34	36	38	40	44	46	48	50	42	45	47	50	52	55	57	60	38	41	44	47	50	53	30	34	37	40	27	30	34
	11	12	13	13	27	28	29	31	32	34	52	54	56	58	60	62	64	66	62	64	67	69	72	74	77	79	56	58	61	64	67	70	44	47	50	54	38	42	46
	14	15	16	17	35	37	38	40	41	42	68	70	72	74	76	78	80	82	82	84	87	89	92	94	97	99	73	76	79	82	85	88	57	60	64	67	49	53	57
	1	2	2	3	1	3	4	6	7	8	2	4	6	8	10	12	14	16	2	5	7	10	12	15	17	20	3	6	9	12	15	18	3	7	10	13	4	8	11
	4	5	6	7	10	11	13	14	16	17	18	20	22	24	26	28	30	32	22	25	27	30	32	35	37	40	20	23	26	29	32	35	17	20	24	27	15	19	23
	8	8	9	10	18	20	21	23	24	25	34	36	38	40	44	46	48	50	42	45	47	50	52	55	57	60	38	41	44	47	50	53	30	34	37	40	27	30	34
	11	12	13	13	27	28	29	31	32	34	52	54	56	58	60	62	64	66	62	64	67	69	72	74	77	79	56	58	61	64	67	70	44	47	50	54	38	42	46
	14	15	16	17	35	37	38	40	41	42	68	70	72	74	76	78	80	82	82	84	87	89	92	94	97	99	73	76	79	82	85	88	57	60	64	67	49	53	57
	1	2	2	3	1	3	4	6	7	8	2	4	6	8	10	12	14	16	2	5	7	10	12	15	17	20	3	6	9	12	15	18	3	7	10	13	4	8	11
	4	5	6	7	10	11	13	14	16	17	18	20	22	24	26	28	30	32	22	25	27	30	32	35	37	40	20	23	26	29	32	35	17	20	24	27	15	19	23
	1	2	2	3	1	3	4	6	7	8	2	4	6	8	10	12	14	16	2	5	7	10	12	15	17	20	3	6	9	12	15	18	3	7	10	13	4	8	11
	4	5	6	7	10	11	13	14	16	17	18	20	22	24	26	28	30	32	22	25	27	30	32	35	37	40	20	23	26	29	32	35	17	20	24	27	15	19	23
	1	2	2	3	1	3	4	6	7	8	2	4	6	8	10	12	14	16	2	5	7	10	12	15	17	20	3	6	9	12	15	18	3	7	10	13	4	8	11
	4	5	6	7	10	11	13	14	16	17	18	20	22	24	26	28	30	32	22	25	27	30	32	35	37	40	20	23	26	29	32	35	17	20	24	27	15	19	23
	1	2	2	3	1	3	4	6	7	8	2	4	6	8	10	12	14	16	2	5	7	10	12	15	17	20	3	6	9	12	15	18	3	7	10	13	4	8	11
	4	5	6	7	10	11	13	14	16	17	18	20	22	24	26	28	30	32	22	25	27	30	32	35	37	40	20	23	26	29	32	35	17	20	24	27	15	19	23

Volume in cords per acre — Add the last figure used in each block together and then divide the total by the number of point samples tallied.

INDIVIDUAL TREE MEASUREMENT

In this system, the diameter and merchantable height of the trees marked for harvest are measured and recorded. The Composite Volume Table (Exhibit 5) is used to tabulate the volume of each tree measured; these figures are then added to obtain the total sales volume. In 100-percent tree measurement sales, this process is tedious and time consuming. The Cordwood Marking Sheet (Exhibit 6) was developed to simplify

Exhibit 5

COMPOSITE TABLE: GROSS VOLUME IN ROUGH CORDS TO A VARIABLE TOP DIAMETER INSIDE BARK, BY NUMBER OF 8-FOOT BOLTS[1] (Gevorkiantz and Olsen 1955)

Diameter breast high (inches)	Volume when number of bolts is—							
	1	2	3	4	5	6	7	8
	Cords	*Cords*	*Cords*	*Cords*	*Cords*	*Cords*	*Cords*	*Cords*
4	**0.007**	**0.011**	----	----	----	----	----	----
5	.011	.019	**0.022**	----	----	----	----	----
6	.017	.028	.040	**0.047**	----	----	----	----
7	.023	.038	.053	.068	**0.076**	----	----	----
8	.031	.050	.068	.087	.106	**0.116**	----	----
9	.040	.065	.088	.109	.130	.153	**0.170**	----
10	.049	.082	.111	.133	.160	.188	**.211**	----
11	.060	.100	.137	.165	.190	.221	**.250**	**0.270**
12	.070	.121	.165	.198	.225	.260	.300	**.330**
13	.082	.143	.197	.236	.268	.305	.350	.42
14	.095	.167	.228	.273	.311	.353	.40	.47
15	.107	.193	.262	.318	.364	.41	.46	.52
16	.122	.220	.300	.367	.42	.47	.53	.59
17	.138	.250	.340	.42	.48	.54	.59	.66
18	.155	.282	.382	.47	.55	.60	.65	.73
19	.173	.318	.43	.53	.61	.68	.73	.81
20	.194	.353	.48	.59	.68	.76	.81	.89
21	.217	.395	.54	.66	.76	.84	.90	.98
22	.240	.44	.60	.73	.84	.93	1.00	1.07
23	.262	.48	.66	.80	.92	1.03	1.10	1.17
24	.288	.52	.72	.88	1.00	1.12	1.21	1.28
25	.312	.58	.78	.96	1.10	1.23	1.33	1.38
26	.340	.62	.84	1.04	1.19	1.33	1.44	1.51
27	.363	.67	.91	1.13	1.29	1.45	1.56	1.63
28	.388	.72	.97	1.20	1.38	1.55	1.67	1.76
29	.41	.76	1.03	1.29	1.49	1.66	1.80	1.90
30	.43	.80	1.10	1.37	1.59	1.7	1.93	2.04

[1] The bold figures in the upper portion of the table are to a minimum top diameter (inside bark) of 3.0 or more, but less than 4.0 inches. Other top diameters are variable but not less than 4.0 inches.

Exhibit 6

CORDWOOD MARKING SHEET WITH CORDS PER TREE

Woodland owner_____ Town_____ Date_____

Grand total # trees marked_____ Grand total vol._____Cords

# 8-ft. logs to 4-in. top	Tree Diameter (Inches)							
	4	6	8	10	12	14	16	18
2	.02	.03	.05	.08	.12	.17	.22	.27
3	.03	.04	.07	.11	.16	.23	.30	.38
4			.09	.13	.20	.27	.37	.49
5			.11	.16	.23	.31	.42	.54
6				.19	.26	.35	.47	.61
7					.30	.40	.53	.68

the task of determining total sales volume. The tally eliminates the need to record tree information in the field, and reduces the time spent in the office calculating tree volumes.

The Cumulative Volume Cordwood Tally Sheet (Exhibit 7) is a quick and easy way to record tree volumes. The advantage of this tally is that block totals can be added quickly, and the total volume determined simply by multiplying the sum by .02. It is the preferred tally, both for 100-percent and sample-tree measurement.

While a forester has a choice of point sampling, 100-percent, or sample-tree measurement to determine firewood sales volumes, an accurate method that is the quickest and most economical is sample-tree measurement, especially for smaller sales (20 acres or less). Pole stands from which much of the firewood can originate tend to be quite uniform, making this sampling system an efficient way of estimating volume. It is preferred over point sampling because measuring the diameter and height of a sample tree is easier and less time consuming than taking a sample point; most firewood sales do not cover large areas, and no estimation of sale area is needed.

CUMULATIVE VOLUME CORDWOOD TALLY SHEET

Based on Composite Volume Tables by the Lake States Forest Experiment Station -- 1943

FORM 2105 . . . H. NIEDECKEN COMPANY, MILWAUKEE, WIS., PRINTED IN U. S. A.

NAME _____ CORDWOOD

COUNTY _____ DATE _____

STATE _____ ESTIMATOR _____

SECTION _____ TWP. _____ RANGE _____ FORTY _____

UNPEELED VOLUME IN TENTHS OF CORDS (Reduce 12% for peeled volume)

DBH	NUMBER OF 8 FOOT BOLTS PER TREE							TOTAL CORDS PER ACRE
	1	2	3	4	5 (Variable top to 4" dib.)	6	7	
6	1 2 3	2 3 4 6 8 9	2 4 6 9	3 6 9	PLOTS TALLIED			
	4 4 5	10 12 14 15 16 18	11 13 15 17	12 14 17				
	6 7 8	20 21 22 24 26 27	19 22 24 26	20 23 26				
	9 10 11	28 30 32 33 34 36	28 30 32 34	29 32 35	LEGEND & CULL %			
	12 13 14	38 39 40 42 44 45	37 39 41 43	38 41 44				
	14 15 16	46 48 50 51 52 54	45 47 49 52	46 49 52				
	17 18 19	56 57 58 60 62 63	54 56 58 60	55 58 61				
	20 21 22	64 66 68 69 70 72	62 64 67 69	64 67 70	5			
	22 23 24	74 75 76 78 80 81	71 73 75 77	72 75 78				
8	2 3 5	2 5 8 10 12 15	3 7 10 14	5 9 14	6 12 17	NEAR MERCHANTABLE TREES		
	6 8 10	18 20 22 25 28 30	18 21 24 28	18 23 28	23 29 35			
	11 13 14	32 35 38 40 42 45	32 35 38 42	32 37 41	41 46 52			
	16 18 19	48 50 52 55 58 60	46 49 52 56	46 51 55	58 64 70			
	21 22 24	62 65 68 70 72 75	60 63 66 70	60 64 69	75 81 87			
	26 27 29	78 80 82 85 88 90	74 77 80 84	74 78 83	93 99 104			
	30 32 34	92 95 98 100 102 105	88 91 94 98	87 92 97	110 116 122			
	35 37 38	108 110 112 115 118 120	102 105 108 112	101 106 110	128 133 139	6		
	40 42 43	122 125 128 130 132 135	116 119 122 126	115 120 124	145 151 157			
10	2 5 7	4 7 11 15 18 22	5 10 15 20	7 13 20	8 17 25	10 20		
	10 12 15	26 29 33 36 40 44	25 30 35 40	26 33 40	33 42 50	30 40		
	17 20 22	47 51 55 58 62 66	45 50 56 61	46 53 59	58 67 75	50 60		
	24 27 29	69 73 77 80 84 88	66 71 76 81	66 73 79	84 92 100	70 80		
	32 34 37	91 95 99 102 106 110	86 91 96 101	86 92 99	109 117 125	90 100		
	39 42 44	113 117 120 124 128 131	106 111 116 121	106 112 119	134 142 150	110 120		
	47 49 51	135 139 142 146 150 153	126 131 136 141	125 132 139	159 167 175	130 140	7	
	54 56 59	157 161 164 168 172 175	146 152 157 162	145 152 158	184 192 200	150 160		
12	3 7 10	5 10 15 20 25 30	7 14 21 28	9 18 27	11 22 34	14 27	16 32	
	14 18 21	35 40 45 50 55 60	34 41 48 55	36 45 54	45 56 68	41 54	49 65	
	24 28 32	65 70 75 80 85 90	62 69 76 83	63 72 81	79 90 101	68 81	81 97	
	35 38 42	95 100 105 110 115 120	90 97 104 110	90 99 108	112 124 135	95 108	113 130	
	46 49 52	125 130 135 140 145 150	117 124 131 138	117 126 135	146 158 169	122 136	146 162	
14	5 10 14	7 13 20 27 34 40	9 18 27 36	12 23 35	15 29 44	18 35	21 42	
	19 24 28	47 54 60 67 74 80	45 54 63 72	47 58 70	58 73 87	53 70	63 84	
	33 38 43	87 94 100 107 114 121	81 90 98 107	82 93 105	102 116 131	88 105	105 126	
16	6 12 18	8 17 25 33 42 50	11 22 33 44	14 29 44	18 36 54	22 44	26 52	
	24 30 36	58 67 75 84 92 100	56 67 78 89	58 72 87	72 90 108	66 87	78 104	
18	8 15 22	10 20 31 41 51 62	14 27 40 54	18 35 52	22 44 66	27 53	32 63	
20	9 18 28	12 25 37 49 62 74	16 32 48 64	21 42 62	26 52 78	32 63	38 76	
22	11 22 33	15 29 44 58 73 88	19 38 56 75	24 49 74	31 61 92	37 74	44 88	

(A) MULTIPLY the SUM of the last figures used in each block by 0 1 ••••(1) For VOLUME PER ACRE divide this product by the NUMBER of 1/5 acre plots --(2) For MARKING TALLY VOLUME divide the product from A by 5

Sample-tree measurement requires greater care in its application than 100-percent tree measurement. All marked trees must be counted using a "tally whacker," the selection of the sample tree must be free of bias, and the measurements must be accurate. Total sales volume is determined by multiplying the total number of trees marked by the average volume of the sample trees, which is expressed in the following formula:

$$\frac{\text{total volume of sample trees}}{\text{total number of sample trees}} \times \text{total number of trees marked}$$

Statistical analysis

Statistical procedures for determining sampling intensities of a pole stand for firewood are well established. The Service Forester's Handbook and Timber Management Field Book are ready reference sources. If the coefficient of variation (C.V.) and the allowable error are known, then the number of samples needed are easily determined. The C.V. is a statistical measurement of variation among sampled individuals in the population. The more uniform the stand, the lower the C.V.

Formula:

$$\text{Coefficient of variation} = \sqrt{\left[\frac{n}{n-1}\right]\left[\frac{n\Sigma x^2}{(\Sigma x)^2}\right] - 1.0} \times 100$$

Where: n = Number of samples
x = Sample volume (or B.A.)

Note: For n greater than 30, $\left[\frac{n}{n-1}\right]$ can be ignored.

Sample calculation:

Sample tree #	Cords/Tree (X)	X^2
1	.01	.0001
2	.02	.0004
3	.04	.0016
4	.03	.0009
5	.05	.0025
	.15 = Σ X	.0055 = ΣX^2

$n = 5$

$\Sigma X^2 = .0055$

$\Sigma X = .15$

$(\Sigma X)^2 = .0225$

$$\text{Coefficient of variation} = \sqrt{\left[\frac{5}{4}\right]\left[\frac{5 \times .0055}{.0225}\right] - 1} \times 100$$

$$= \sqrt{[1.25]\ [1.22] - 1} \times 100$$

$$= \sqrt{.275} \times 100$$

$$= 52\%$$

While the formula for the determination of C.V. is easy to use, it requires the tabulation of field data and desk calculations that are time consuming. In his "Reference Handbook for Foresters," Ashley has identified a shortcut procedure for computing the C.V. as follows:

1. Determine range of samples by subtracting low sample from high sample. This is (R)
2. Refer to Table 1 to determine factor.
3. Multiply (R) by factor—answer is Standard Deviation (S.D.).
4. Divide S.D. by the mean (M)—answer is C.V.

The mean can be determined by adding the low sample and the high sample together and dividing by 2.

Using the above sample calculation as an example:

1. $R = .05 - .01 = .04$
2. Factor from Table I (5 samples) is .430.
3. $SD = R \times \text{Factor}$
   $SD = .04 \times .430 = .0172$
4. $\text{Mean (M)} = \dfrac{.01 + .05}{2} = .03$

$$CV = \frac{SD}{M} = \frac{.0172}{.03} = 57\%$$

Although there is a difference in C.V. values between the two methods, the difference is small causing a minor influence on number of samples.

Table 1. — Ratio of standard deviation to range for simple random samples (Snedecor 1956)

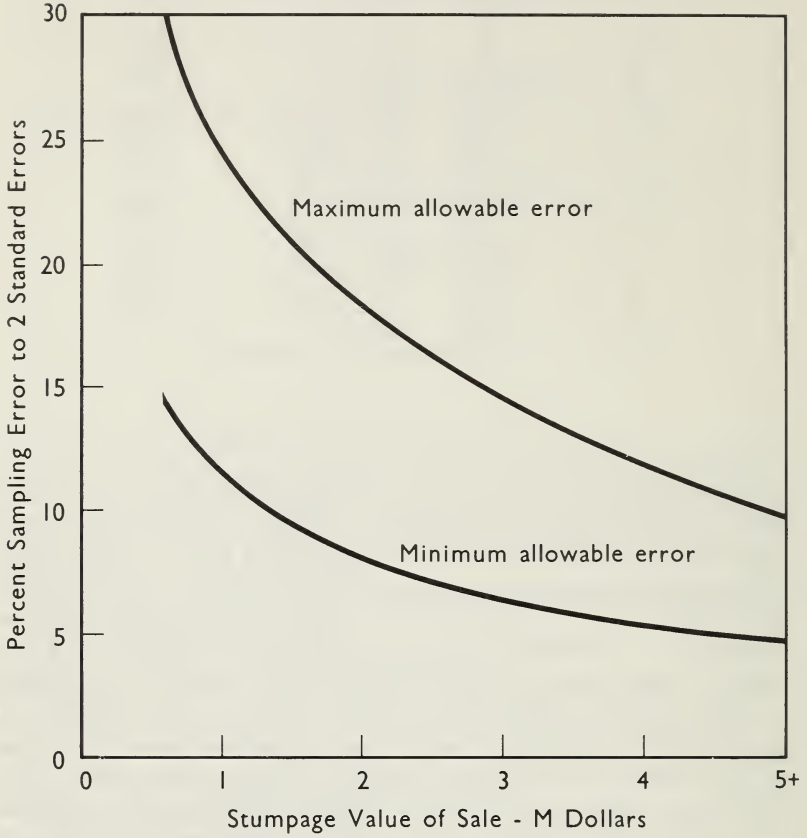
N	$\frac{SD}{R}$	N	$\frac{SD}{R}$
2	0.886	12	0.307
3	.591	14	.294
4	.486	16	.283
5	.430	18	.275
6	.395	20	.268
7	.370	30	.245
8	.351	40	.231
9	.337	50	.222
10	.325		

Estimates of C.V. can be obtained from data on previous sales or experienced judgment. Usually, a hardwood pole stand from 5 to 10 inches dbh will have a C.V. of from 40 to 50 percent. If large wolf trees are encountered — 11 inches dbh and larger — they should not be part of the sampling unit but measured as a separate unit on a 100-percent basis. This will protect the low C.V. value and reduce sampling intensity.

The allowable error or sampling error is the standard of accuracy for a particular sale volume determination. It is based on the value of the timber product which, in this case, is the stumpage value of firewood. Presale measurement standards of accuracy for sample tree measurement and area estimate sales are shown in Figure 3. It describes both a minimum and a maximum sampling intensity. For example, a sale worth more than $2,000 should have a sampling error of about 18 percent or less to 2 standard errors (19 times out of 20) before it is offered for sale. This may be regarded as the maximum allowable sampling error, or minimum sample intensity desirable for firewood sales. The same sale should not have a sampling error of less than 8 percent to 2 standard errors (19 times out of 20). This may be regarded as the minimum allowable sampling error, or maximum sample intensity. As a matter of efficiency, sampling should be designed for the maximum rather than the minimum allowable error.

For an average firewood sale of 10 acres, the stumpage value might be close to $1,000. This means a sampling error of 24 percent. Assuming an average pole stand, the C.V. would be

PRESALE MEASUREMENT FOR STANDARDS OF ACCURACY FOR TREE MEASUREMENT AND AREA ESTIMATE SALES



close to 40 percent. The following is an example of a cruise design for this sale.

- Sales value: $1,000
- Number of sample units: 1 unit—poles 4 to 10 inches dbh. Larger trees to be measured separately on 100-percent tree measurement basis.
- C.V., 40 percent
- E Allowable error (from Fig. 3), 24 percent
- N 1000 (It is estimated that 100 trees/acre will be harvested)
- n Number of samples needed
- Sale to be marked and thinned for firewood

$$\bullet\ n = \frac{(2\ C.V.)^2}{E^2} = \frac{(2 \times 40)^2}{24^2} = \frac{6400}{576} = 11 \text{ samples}$$

If our estimate of 1,000 trees for the entire sale is correct, we would measure every 90th tree. To be assured of obtaining enough samples, it might be well to measure 1 tree in 80. After the sale area is marked, calculate the actual C.V. and limit of error using measured data of the sampled trees.

CONCLUSION

Use silvicultural guides in managing young hardwoods for firewood. Each stand should be examined closely, and a prescription should be prepared using the proper stocking chart. The stand prescription is the difference between the present stocking and B level, and is expressed in square feet of basal area and number of trees per acre to be removed or spacing of residual crop trees.

The intended goal of thinning hardwoods is to develop an adequately stocked stand with an even distribution of crop trees. Avoid creating understocked stands below the B level.

Through the firewood market one has an opportunity to increase the white pine component of stands on lighter, sandy soils where white pine seedling and saplings are growing in the understory of hardwoods. Many spruce-fir and hemlock stands can be improved as well by removing the hardwood competitors for firewood.

There are two methods used in estimating tree volumes for firewood sales—point sampling for area estimate sales and individual-tree measurement. For large firewood operations of 50 acres or more, point sampling is appropriate. For small sales, 10 or 20 acres, the most economical and an accurate method is sample-tree measurement.

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